



p̄ Note #405

TRIP REPORT

Sept, 15     Oct. 10, 1984

A.G. Ruggiero

(10/22/84)

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SEPT. 15, OCT. 10, 1984

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1. GENEVA, SWITZERLAND

I ARRIVED IN GENEVA THE AFTERNOON OF SUNDAY, SEPTEMBER 16. I TOOK A TAXI AND WENT STRAIGHT TO CERN WHERE I GOT MY ROOM. I SPENT THE ENTIRE FOLLOWING WEEK VISITING CERN. MY ACTIVITIES WERE DIVIDED BETWEEN THE PS DIVISION AND THE SPS DIVISION.

AT THE PS DIVISION I MET WITH PEOPLE WORKING AT THE ANTIPROTON SOURCE. I ATTENDED A GROUP MEETING ON MONDAY AND A SO-CALLED "INTERNATIONAL" MEETING ON TUESDAY. DURING THE FIRST ONE THERE WERE TECHNICAL DISCUSSIONS FOR THE PREPARATION OF THE NEXT RUN WHICH WAS SUPPOSED TO START THE FOLLOWING WEEK-END. DURING THE MEETING I LEARNED THE FOLLOWING, NOTABLY FROM S. VANDERMEER:

(I) FOR STABILITY CONSIDERATIONS, WHICH INVOKES A DEPENDENCE ON THE SIGN OF THE DERIVATIVE OF THE ENERGY DISTRIBUTION, PULSES OF ANTIPROTONS ARE EXTRACTED FROM THE STACK IN THE AA-RING WITH RF-UNSTACKING FROM A POINT WITHIN THE CORE WHERE THE SLOPE IS NEGATIVE.

(II) RF-UNSTACKING CAUSES A DISPLACEMENT IN MOMENTUM OF THE WHOLE CORE THAT COULD BE APPRECIABLE. TO COMPENSATE FOR THIS AN ANTI-BUCKET, EMPTY, IS SUBSEQUENTLY MOVED THROUGH THE STACK IN THE OPPOSITE DIRECTION.

(III) THE EMITTANCE OF EACH PULSE EXTRACTED FROM THE CORE INCREASES CONSIDERABLY MOVING TOWARD THE EXTRACTION ORBIT, CAUSING INCONVENIENCE DURING EXTRACTION, TRANSPORT AND TO THE PERFORMANCE OF THE P-PBAR COLLIDER. THIS PROBLEM IS SERIOUSLY INVESTIGATED AND IT IS BELIEVED TO BE CAUSED BY THE ELECTRONIC RESPONSE AS THE BEAM MOVES THROUGH THE VARIOUS STOCHASTIC COOLING STAGES DURING RF-UNSTACKING.

AT THE "INTERNATIONAL" MEETING, WHERE ASIDE FROM MYSELF I COULD COUNT ONLY VERY FEW OUTSIDERS, NOTABLY BRITISH, WE WERE GIVEN TECHNICAL PRESENTATIONS ON THE STATUS AND DEVELOPMENT OF THE AA AND ACOL PROJECTS. I LEARNED THE FOLLOWING:

(I) (TED WILSON) A PROGRAM OF IMPROVEMENT FOR THE STOCHASTIC COOLING SYSTEM IS PLANNED FOR THE AA-RING. THE CORE SYSTEM WILL BE REPLACED WITH A 4-8 GHZ BANDWIDTH FOR BETATRON COOLING AND WITH A 2-4 GHZ BANDWIDTH FOR CORE MOMENTUM COOLING. THE 4-8 GHZ SYSTEM WILL BE IMPLEMENTED FIRST. LATER THE WHOLE TAIL-STACK STOCHASTIC COOLING SYSTEM WILL BE RAISED TO 1-2 GHZ. ACCORDING TO THEIR CALCULATIONS THE STACK WILL GET NARROWER AND MORE DENSE; BUT THERE IS NO NEED TO CHANGE THE LATTICE PARAMETERS; IN PARTICULAR  $\chi_1$  WAS LEFT UNCHANGED. THE CHANGES WILL BE IMPLEMENTED DURING THE NEXT ONE OR TWO YEARS. NOT ONLY THEY ARE THOUGHT TO BE NECESSARY TO IMPROVE THE PERFORMANCE OF THE AA-RING BUT ALSO TO TEST

## An Analysis of Accumulator Ring Pressure Data

This note summarizes and analyzes the Accumulator Ring's pressure data taken during the recent commissioning run (March-October, 1985) and during the three week interval immediately after the end of the commissioning run. Emphasis is placed upon the questions raised in reference [1], viz.:

1. What is the ultimate vacuum attainable?
2. How do we calculate the "effective-pressure" for beam lifetime estimates from the ion gauge data?
3. What is the required sublimation schedule to maintain adequate vacuum?

### I. Historical Perspective

Throughout the TEV-1 commissioning run the mean pressure in the Accumulator Ring<sup>(2)</sup> was gradually reduced by sporadic leak-hunting, baking, and sublimating on a "catch-as-catch-can" basis. By the end of the run a mean pressure of  $1.6 \times 10^{-9}$  Torr. had been achieved - in contrast to the Design Report's average pressure of  $3.0 \times 10^{-10}$  Torr.

Early in October, 1985, at the conclusion of the commissioning run, the TEV-1 Vacuum Group began a program of systematic leak-checking and sublimating. After several weeks of painstaking work, the mean pressure in the Accumulator Ring had been reduced to  $2.9 \times 10^{-10}$  Torr. Shortly thereafter several sectors of the ring were let-up to atmosphere for equipment modification. Consequently, the analysis here concentrates on data taken after the conclusion of the commissioning run but before the ring was let-up to air.

### II. Analysis of Ion Gauge Readings

The pirani, cold-cathode and ion pump readback instrumentation are intended primarily to monitor the progress of the Accumulator Ring pump-down; only the twenty-four ion gauges are available for measuring the pressure in the UHV design region. In attempting to understand the ion gauge readings, it is useful to separate the data into two categories - readings from ion gauges mounted on tanks vs. those mounted directly on the the chamber - since they sample fundamentally different environments.

WITH BRUNO AUTIN I HAD AGAIN DISCUSSIONS THIS TIME ON THE PROPER COLLECTOR LENS FOR A VERY HIGH PRODUCTION RATE OF ANTIPROTONS ALSO AT HIGH REPETITION RATE. IT SEEMS THAT THE LITHIUM LENS WILL EVENTUALLY COME TO A LIMIT AND THAT A PLASMA LENS IS MORE CONVENIENT AND BETTER SUITED FOR A PBAR SOURCE FEEDING A P-PBAR SSC COLLIDER. SOME PAPERS ALREADY EXIST TO SUPPORT THIS.

FINALLY I MADE A VERY SHORT VISIT TO THE LEP GROUP. WE HAD A MEETING OF ABOUT AN HOUR CALLED BY E. KEIL, I BELIEVE, TO EXCHANGE INFORMATIONS AND OPINIONS ON SSC AND LHC ALSO BECAUSE SEVERAL PEOPLE FROM USA HAPPENED TO BE THERE. ASIDE FROM MYSELF, E. COURANT AND I. CLAUS (BNL) WERE ALSO PRESENT. WE DISCUSSED PERFORMANCE, MAGNETS, THE CHOICE OF THE NATURAL EMITTANCE AND WE EXCHANGED OPINIONS, SOMETIME NOT VERY OBJECTIVE, ON THE PROTON-ANTIPROTON ALTERNATIVE ISSUE.

AS USUAL MY VISIT TO CERN HAS BEEN USEFUL, FRUITFUL AND BUSY. THIS TIME THOUGH I FOUND MYSELF IN THE MIDST OF THE 30TH ANNIVERSARY CELEBRATION OF THE FOUNDATION OF CERN. AN EVENT THAT I FOUND CONFUSING AND ANNOING FOR MY TASTE, ESPECIALLY BECAUSE VISITS OF EUROPEAN MONARCHS AND AUTHORITIES AND THEIR SPEACHES. NONETHELESS I ENJOYED A CONCERT THAT WAS GIVEN FOR THE OCCASION AT THE GRAND THEATRE TO WHICH I HAVE BEEN INVITED.

I LEFT GENEVA SUNDAY MORNING, SEPTEMBER 23, BY TRAIN, MY NEXT DESTINATION BEING KARLSRUHE IN WEST GERMANY.

## 2. KARLSRUHE, WEST GERMANY

I ARRIVED TO KARLSRUHE IN THE AFTERNOON, WENT TO THE HOTEL WHERE I HAD THE RESERVATION MADE AND LATE IN THE EVENING ATTENDED THE RECEPTION PARTY AT THE SCHLOSSHOTEL.

I STAYED IN KARLSRUHE TWO DAYS TO ATTEND ACOOL 84, THE WORKSHOP ON ELECTRON COOLING. ON THE SECOND DAY I GAVE MY TALK, SINCE I HAVE BEEN INVITED TO, ON THE USE OF RELATIVISTIC ELECTRON COOLING FOR PROTON-ANTIPROTON COLLIDERS AT LARGE ENERGIES AND THE LIMITATIONS CAUSED BY INTRABEAM SCATTERING. I AM PREPARING A PAPER ON THE SUBJECT AS REFERENCE FOR MY TALK WHICH WILL APPEAR IN THE PROCEEDINGS OF THE CONFERENCE.

THE AGENDA WAS QUITE BUSY BUT A VERY INTERESTING ONE. MOST OF THE APPLICATIONS ARE FOR NUCLEAR PHYSICS AND LOW AND MEDIUM ENERGY. I FOUND THE TECHNOLOGY FOR ELECTRON GUNS AND COLLECTORS GREATLY IMPROVED AND QUITE RELIABLE FOR THESE DAYS STANDARD. IN PARTICULAR I ENJOYED A TALK BY FRANK KRIENEN ON THE IDEA OF A HOLLOW CATHODE WHICH WOULD REMOVE THE NEED OF CUMBERSOME BENDING OF THE ELECTRON BEAM IN AND OUT OF THE ION BEAM.

TWO SOVIET PHYSICISTS WERE PRESENT FROM NOVOSIBIRSK: PESTRIKOV AND PARKHOMCHUK. THEY CIRCULATED A NOTE AND A GAVE A COUPLE OF TALKS ON AN ISSUE WHICH IN MY OPINION IS RATHER CONTROVERSIAL. THEY CLAIM THAT ELECTRON COOLING WOULD HELP AN ION BEAM TO ACQUIRE WHAT IS CALLED AN ORDERED STATE BY COULOMB REPULSION, WHERE THE PARTICLES ASSUME AN EQUI-SPACED DISTRIBUTION. THIS STATE OF MATTER IS OF INTEREST TO

NUCLEAR PHYSICISTS BECAUSE THAT BEAM COULD BEHAVE LIKE A CRYSTAL. IF PERTUBED, IT WOULD RESPOND BY RIGID OSCILLATIONS. I HAVE THE PAPER WITH ME AND PLAN TO STUDY IT AND TRY TO MAKE ANY SENSE OUT OF IT.

ELECTRON COOLING COULD BE OF SOME USE TO TEVATRON I AT FERMILAB IN TWO PARTICULAR SITUATIONS. MEDIUM ENERGY COOLING COULD BE INTEGRATED WITH STOCHASTIC COOLING IN THE ACCUMULATOR RING TO ENHANCE THE DENSITY IN THE CORE. RELATIVISTIC COOLING HAS SOME MERIT IN MY OPINION IN THE COLLIDER SINCE IT COULD REDUCE BY A FACTOR OF TWO THE REQUIRED NUMBER OF ANTIPROTONS ( AND THEREFORE THE FILLING TIME ) BY SHRINKING BOTH BEAMS EMITTANCE BY A FACTOR OF FOUR. IT COULD OF COURSE LENGTHEN THE USEFUL LUMINOSITY LIFETIME AGAINST PHENOMENA LIKE INTRABEAM SCATTERING.

I LEFT KARLSRUHE THE EVENING OF SEPT. 23 DIRECTED TO ROME IN ITALY. THE FOLLOWING DAY I WENT TO THE LABORATORI NAZIONALI DI FRASCATI WHERE I WAS INVITED TO ATTEND THE WORKSHOP TO THE NEW METHODS OF ACCELERATION TO VERY LARGE ENERGIES.

### 3. FRASCATI, ITALY

THE WORKSHOP LASTED ONE WHOLE WEEK: SEPT. 23 - OCT. 1. IT STRESSED THE NEED OF STUDYING NEW TECHNIQUES TO ACCELERATE CHARGED PARTICLES TO LARGE ENERGIES OVER SHORT DISTANCES. SEVERAL IDEAE HAVE ALREADY BEEN CIRCULATING ON THE SUBJECT AND THIS WAS BY NO MEANS THE FIRST WORKSHOP OF THE KIND. ACTUALLY IT WILL BE FOLLOWED SOON, JANUARY 1985, BY ANOTHER WORKSHOP TO BE HELD IN MALIBOU BEACH, CALIFORNIA. THE NEW TECHNIQUES CLAIM LARGE ACCELERATION GRADIENTS: FROM A FRACTION OF ONE GEV TO SEVERAL, IF NOT TENS, OF GEV PER METER. THEY ARE MOST USEFUL TO ACCELERATE ELECTRONS AND POSITRONS, ON PRACTICALLY LINEAR PATHS.

ON THE OPENING DAY (WHICH I MISSED) CARLO RUBBIA GAVE HIS OWN PRESCRIPTION ON THE REQUIREMENTS OF A LINEAR COLLIDER WITH ELECTRONS AND POSITRONS. ENERGIES OF 1 TEV PER BEAM AND LUMINOSITY OF  $10^{32} \text{ cm}^{-2} \text{ s}^{-1}$  ARE REQUIRED TO COMPETE POSSIBLY WITH THE EQUIVALENT LARGE HADRON-HADRON COLLIDERS IN CIRCULAR GEOMETRY (SSC, LHC). ONE STEP BEYOND THIS WOULD REQUIRE ENERGIES AS LARGE AS 10 TEV PER BEAM BUT LUMINOSITY AS HIGH AS  $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ .

THERE WERE ABOUT A HUNDRED EXPERTS ATTENDING THE WORKSHOP. THEY WERE DIVIDED IN FOUR MAIN GROUPS:

GROUP 1.) FAR FIELD DEVICES. THIS IS MADE MAINLY OF INVERSE FREE ELECTRON LASER (IFEL) TECHNIQUES WHERE THE ENERGY PUMPED TO A FREE ELECTRON LASER IS USED IN AN INVERSE MODE OF OPERATION AND DELIVERED TO AN ELECTRON BEAM. THIS DEVICE IS MAINLY LIMITED BY THE AMOUNT OF SYNCHROTRON RADIATION WHICH IS A VERY DOMINANT EFFECT. MAXIMUM ENERGIES ARE ESTIMATED IN THE PROXIMITY OF THE 300 GEV.

GROUP 2.) NEAR FIELD DEVICES. THERE ARE SEVERAL POSSIBILITIES. ONE CAN START WITH A CONVENTIONAL LINAC LIKE SLAC BUT AT CONSIDERABLE SMALLER

WAVELENGTH (1CM, 30 GHZ) TO OBTAIN LARGE ACCELERATION GRADIENTS, ABOUT 100 MEV/M. THE MAJOR PROBLEM IS TO DEVELOP A POWER SOURCE AT THE CHOSEN FREQUENCY. SEVERAL IDEAS DO NOW EXIST: KLYSTRON, LASERTRONS, GYROTRONS,... BUT THEIR EFFICIENCY AND TOTAL POWER ARE STILL SUBJECT OF INVESTIGATION.

TWO BEAM ACCELERATORS (WEILAND, VOSS) ARE THOSE MADE OF TWO PARALLEL RF STRUCTURES, ONE TRAVERSED BY THE SOURCE BEAM (ELECTRONS) WHICH LOOSES ITS ENERGY TO THE DEVICE, AND THE OTHER, ELECTROMAGNETICALLY COUPLED TO THE FIRST, TRAVELLED BY THE PRIMARY BEAM WHICH IS ACCELERATED BY RECOVERING THE ENERGY LOST BY THE FORMER. CLEARLY THE DEVICE ACTS LIKE A TRANSFORMER AND THE RATIO OF TRANSFORMATION, INVOLVING BEAM QUALITY, ENERGY AND INTENSITY, IS THE MAJOR PARAMETER OF INVESTIGATION.

IN THE SAME CATEGORY WE HAVE ALSO THE WAKE-FIELD TRANSFORMER. THIS HAS BEEN MY MAJOR CONCERN AT THE WORKSHOP AS IT HAS BEEN BEFORE IT AND I HOPE IT WILL BE ALSO IN THE FUTURE. THE DEVICE HAS BEEN ALSO CALLED A "PROTON-KLYSTRON" AND IT IS MADE OF SHORT WAVELENGTH RF STRUCTURE ( ABOUT ONE MILLIMETER) TRAVERSED FIRST BY A TIGHT BUNCHED BEAM OF PROTONS AS OBTAINED FROM CONVENTIONAL SYNCHROTRONS. THE PROTONS LOOSE THEIR ENERGY TO THE CAVITIES WHICH IS THEN RECOVERED BY A LESS INTENSE ELECTRON BUNCH TRAVELLING BEHIND AT A CONVENIENT DISTANCE. I MADE FEW PRESENTATIONS OF THIS IDEA DURING THE WORKSHOP AND PLAN TO SUBMIT A PAPER WITH MORE DETAILS FOR THE PROCEEDINGS OF THE WORKSHOP.

FINALLY, R. PALMER HAS PROPOSED A DEVICE MADE OF DROPLET STRUCTURE MODULATED SO TO PRODUCE VERY HIGH NEAR FIELD. SEVERAL GEV/M ARE HOPED FOR AND THE BREAKDOWN LIMIT IS AVOIDED BY USING DISPOSABLE DROPLETS MADE CONDUCTIVE BY FORMING TRANSIENT PLASMA ON THEIR SURFACE. THIS TECHNIQUE IS STILL IN EXPLORATION STAGE AND IT WILL TAKE SOME TIME BEFORE IT COULD BECOME PRACTICAL.

GROUP 3.) MEDIA ACCELERATORS. OF SEVERAL DEVICES STUDIED, PLASMA BEAT-WAVE SEEMS MOST ENTICING. THEY ARE EITHER ELECTRON OR LASER EXCITED. LASER EXCITATION IS THE MOST STUDIED AND SEEMS TO BE THE MORE EFFICIENT. THE METHOD REQUIRES A TIGHTLY FOCUSED LASER BEAM PULSE TO ORGANIZE A PLASMA BY EXCITING LONGITUDINAL LANGMUIR WAVES WHICH CAN ACCELERATE PARTICLES BECAUSE OF THE RESULTING ELECTRIC FIELD.

GROUP 4.) ACCELERATOR ISSUES. I SPENT A CONSIDERABLE FRACTION OF MY TIME WITH THIS GROUP. SEVERAL ISSUES WERE DISCUSSED TO CHECK LIMITATIONS AND REQUIREMENTS FROM THE ACCELERATOR PHYSICS POINT OF VIEW FOR THE VARIOUS METHODS DISCUSSED IN THE OTHER GROUPS. IN PARTICULAR A CONSENSUS WAS CREATED ON A LIST OF PARAMETERS FOR THE BEAM PROPERTIES WHICH ARE REQUIRED FOR A HIGH PERFORMANCE COLLIDER. THE CASE OF 1 TEV ON 1 TEV ELECTRON-POSITRON COLLIDERS WITH LUMINOSITY OF  $10^{32} \text{ cm}^{-2} \text{ s}^{-1}$  WAS CONSIDERED POSSIBLE WITH TODAY'S TECHNOLOGY, WHEREAS THE OTHER EXTREME OF 10 TEV PER BEAM AND LUMINOSITY OF  $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  IS QUITE MORE DIFFICULT AND FOR THE MOMENT OUT OF REACH. THE MAIN LIMITATIONS, FOR A GIVEN AMOUNT OF POWER ONE IS WILLING TO PAY FOR, ARE IN THE BEAM REPETITION RATES AND THE SMALLEST BEAM DIMENSIONS THAT ONE CAN ACHIEVE

AT THE COLLISION POINT. BEAM SPOTS WITH DIMENSIONS AS SMALL AS  $50 \text{ \AA}$  COULD BE REQUIRED.

THE ORGANIZATION OF THE WORKSHOP WENT ON VERY SMOOTHLY AND QUITE EFFICIENTLY. IT WAS SPONSERED BY CERN AND ORGANIZED BY CERN STAFF WITH HELP OF THE LOCAL STAFF OF THE FRASCATI LABORATORY. THIS MIXED RELATIONSHIP WORKED WELL EXCEPT IN ONE OCCASION WHEN WE HAD PROBLEM WITH BUSSING BECAUSE, IN MY OPINION, OF THE ORGANIZERS IGNORANCE OF THE LOCAL SYSTEM. FINALLY I MUST SAY THAT I ENJOYED VERY MUCH AND FOUND VERY CLEVERLY PLANNED THE WORKSHOP OFFICIAL DINNER WITH EXCELLENT FOOD, WINE AND MUSIC ALL BLENDED WITH THE LOCAL FOLKLORE.